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FOREIGN TECHNOLOGY DIVISION

PREPARATION OF AERIAL PHOTOGRAPHS FOR ANALYSIS
ON A TOPOGRAPHIC STEREOMETER

by

V. V. Pervozvanskiy

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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α α		Nu	Ν ν	
Beta	Β β		Xi	Ξ ξ	
Gamma	Γ γ		Omicron	Ο ο	
Delta	Δ δ		Pi	Π π	
Epsilon	Ε ε ϵ		Rho	Ρ ρ	
Zeta	Ζ ζ		Sigma	Σ σ	
Eta	Η η		Tau	Τ τ	
Theta	Θ θ ϑ		Upsilon	Τ υ	
Iota	Ι ι		Phi	Φ φ ϕ	
Kappa	Κ ϰ κ ϰ		Chi	Χ χ	
Lambda	Λ λ		Psi	Ψ ψ	
Mu	Μ μ		Omega	Ω ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

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PREPARATION OF AERIAL PHOTOGRAPHS FOR ANALYSIS ON A TOPOGRAPHIC STEREOMETER

V. V. Pervozvanskiy

Aerial photographs should have good measuring properties, which depend on the photographic quality of the aerial negatives, orthoscopicity, and resolution of the photographic image. The quality of aerial negatives is mainly determined by the optical properties of the photography system, the quality of the aerial film, the precision of its alignment in the plane, the aerial photography conditions, and the development of the aerial film. The measuring properties of aerial photographs are also affected by the conditions under which the positives are made, the resolution of the photographic paper, and its deformation.

Aerial photographs printed on photographic paper preliminarily glued onto glass are used for making stereoscopic drawings of relief on a topographic stereometer. However, as of yet no single procedure for gluing the the paper onto glass has been developed, nor is there any one approach to selecting the finish of the paper.

Production subdivisions use both mat and glossy or high-gloss paper. There are different methods of gluing the paper onto glass: some subdivisions and enterprises glue standard 18x18 cm photographic paper onto glass of the same size without any special preparation of the glass; others treat the glass (mat) before gluing on the paper; some enterprises glue 21x23-21x22 cm photographic paper onto 18x18 cm glass, bending the paper and gluing its edges to the underside of the glass.

Mat paper is convenient for drawing figures with a pencil and India ink. However, the lowered maximum density D_{max} and lower value of the range of useful exposure L of this photographic paper result in poorer detail in the picture, which lowers the precision of measurement. Glossy and high-gloss paper (high values of D_{max} and L) lose their advantage when their surface is treated with rubber, which is one way of making it possible to draw on glossy paper with a

pencil and India ink.

The diversity of processes of gluing photographic paper is due to the attempt to eliminate random deformation and its effect on the precision of stereoscopic measurements.

Studies were conducted to determine the advantages of a given type of photographic paper finish and the method of gluing it onto glass, as well as to explain the effect of these factors on the precision of the stereotopographic work done at the North-western Aerogeodesic Enterprise. This study program consisted of:

1) obtaining comparison data on the overall distortion of aerial photographs;

2) detecting local distortions;

3) obtaining comparison data on the resolution of each type of aerial photograph finish;

4) determining the effect of the gluing method and finish of the photographic paper on the precision of stereotopographic work.

The studies were conducted with measuring grids (Gautier) and

aerial photographs on a scale of 1:15,000 (obtained with aerial camera AFA-TE-70), printed on diapositive plates and on different photographic paper:

a) 18x18 cm semi-mat and high-gloss paper preliminarily glued onto glass;

b) 21x23 cm semi-mat and high-gloss paper glued onto glass with the edges bent underneath;

c) 18x18 cm semi-mat and high-gloss paper glued onto glass with a rough mat surface.

The aerial photographs were also printed on photometric plates made by the emulsion-washing laboratory of the enterprise's photography shop. Since prints made on mat paper do not have good clarity, no distortion measurements were made on the pictures printed on mat paper.

The established technological process for gluing the photographic paper onto glass and printing the pictures was followed closely.

The composition of the starch-gelatin glue used at our

enterprise for gluing down the paper was as follows:

Water 1

Starch .... 150 g

Gelatin .... 75 g

Phenol .... 1 g

Special graded test tables, with which reduced negatives and prints on mat, semi-mat, glossy and high-gloss paper were made, were prepared to allow us to make a more objective comparative analysis of the resolution of photographic paper with different finishes.

In order to study the dependence of the total distortion of aerial photographs on the method of gluing the photographic paper onto glass and its finish, the distances were measured on precision stereometer SM-4 in two mutually perpendicular directions between lines 1 cm from the edge for the measuring grids, and between the coordinate marks for the aerial photographs.

Table 1 shows the results of the measurements at a reading accuracy of 0.02 for scales XX and YY. The values (distances)

characterizing distortion are given in millimeters.

The results of the measurements show that the finish of the paper and the different methods of gluing it onto glass do not have a significant effect on the overall distortion - the distortion value turns out to be of the same order of magnitude.

Measurements were made with grids and aerial photographs to reveal local distortions caused by the overall effect of the different methods of gluing the paper onto glass and the different finishes. The differences between the longitudinal and transverse parallaxes were measured at 45 evenly spaced points within the stereogram using the measuring grids on precision stereometer SM-4 with the correctors turned off. Two stereograms were made for each method of measurement; thus, there were 90 points. The precision of the readings from the parallax spirals was up to 0.001 mm. The results of the measurements are given in Table 2, with the parallax values given in thousandths of a millimeter.

Possible local distortions caused by the different methods of gluing the photographic paper onto glass and the finish of the paper were determined from the aerial photographs by the same method used to estimate the alignment of the aerial film in the plane. The transverse parallaxes q and values of x and y were measured on scales

XX and YY on stereometer SM-4 at 15 evenly spaced points within the stereograms. After the curve of the values of ϕ was plotted and the value of q was calculated from formula $q = \phi y$, the measured transverse parallaxes were compared to the preliminarily calculated ones (graphic interpolation method). The measurements were made on two stereograms for each paper finish and method of gluing the paper onto glass. Table 3 shows the mean and maximum values of the divergences $q_{изм} - q_{выч}$, between the measured and preliminarily calculated values of q for 18 points, expressed in thousandths of a millimeter. The data in the table characterize the combined effect of several factors on the distortion of aerial photographs - the method of gluing down the photographic paper, its finish, and also the distortion of the aerial negatives.

It is evident from Tables 2 and 3 that neither the method of gluing the photographic paper onto the glass, nor differences in the emulsion layer finish of the paper have a significant effect on local distortions.

The resolution of photographic paper with different surface emulsion layers was compared by visual observation under a beam with $8-10^{\times}$ enlargement from the special graded test table on photographic paper (graded test object) printed on high-gloss, glossy, semi-mat and mat paper with approximately identical contrast

(No. 3).

The results of observations made by a rather large group of photogrammetrists confirm that mat paper has greatly inferior resolution and lower picture clarity than semi-mat, glossy and high-gloss. The glossy and high-gloss finishes of the graded test object were not treated with rubber in this case. The test object negative had a resolution of R = 107 lines/mm; the semi-mat, glossy and high-gloss - R = 64 lines/mm; and the mat paper - R = 43 lines/mm.

In order to obtain comparison data characterizing the effect of the finish of the photographic paper and the method of gluing it down on the precision of stereotopographic work, the aerial photographs were oriented on a topographic stereometer with two stereograms for each version at a specified height of the check points and the stereoscopic relief drawing. The precision of this operation can be judged from the data in Table 4, which shows the errors in the photogrammetric determination of the heights calculated by the divergences of the geodesic and photogrammetric marks of the check points.

Table 4 shows that the precision of determining the heights was of the same order of magnitude for all the methods of preparing the

aerial photographs for analysis on the topographic stereometer. Somewhat more precise photogrammetric point marks were determined on the diapositive slides. No appreciable differences were detected in the relief drawing.

These studies allow us to make the following conclusions.

1. All of the above methods of gluing photographic paper onto glass and the finishes of the photographic paper (semi-mat, glossy and high-gloss) can be used without lowering the precision of the process. However, it is more expedient to use aerial photographs printed on standard 18x18 cm semi-mat paper glued onto glass without bending the edges. This paper has good resolution and does not make it necessary to preliminarily treat the surface of the aerial photograph with rubber or coat it with various special emulsions, thus increasing the process' efficiency and lowering its cost.

2. The value of gluing large sheets of photographic paper and bending their edges and gluing them to the underside of the glass was not confirmed. This method of gluing the paper is more complicated. Furthermore, this method takes up to 45o/o more paper and has a high percentage of defectiveness.

3. The advisability of preliminarily matting the glass was

not substantiated.

4. When preparing aerial photographs for analysis on a topographic stereometer one should:

a) strictly follow the procedures for gluing down the photographic paper and for photolaboratory processing of aerial photographs - the length of time the prints are in the fixer and in water, the correct method of washing (nondirected jet);

b) grind the edges and corners of the glass to prevent scratching the hands;

c) glue strips of ordinary paper 1 cm wide or a sheet of ordinary roll paper $\approx 16\times16$ onto the edges of the underside of the glass to prevent the glass from slipping off the inclined holder of the instrument;

d) closely check the suitability of aerial photographs for stereoscopic measurements (dabs of glue, blobs, bubbles, etc., should not be seen from the underside of the glass, since this results in distortions).

Aerial photographs for analsysis on a topographic stereometer are

taken one to two years before they are used. Therefore, research on the effect of the method of gluing the paper onto glass on its distortion should be expanded to a broader sphere of commercial materials, making it possible to determine the dependence of deformation of the photographic paper on the length of time aerial photographs are stored at different air temperatures and humidities.

It is advisable to produce photographic paper with a metal insert in the backing layer in order to eliminate the effect of photographic paper deformation on the precision of stereotopographic work.

Table 1.

(1) Направление	(2) Диапозитивы	(3) Фотометрические пластинки	(4) Фотобумага, наклеенная на стекло без загиба краев		(5) Фотобумага, наклеенная на стекло с загибом краев		(6) Фотобумага, наклеенная на матированное стекло	
			(7) полуматовая	(8) особо глянцевая	(7) полуматовая	(8) особо глянцевая	(7) полуматовая	(8) особо глянцевая
			(9) По измерительным сеткам					
XX	160,09	—	160,02	160,07	160,06	160,04	160,08	160,00
YY	160,08	—	160,07	160,04	160,04	160,05	160,06	160,06
			(10) По аэроснимкам					
XX	172,87	172,81	172,81	172,80	172,81	172,79	172,78	172,80
YY	173,09	173,17	173,03	173,02	173,08	173,09	172,99	173,04

KEY: (1) Direction. (2) Diapositives. (3) Photometric plates. (4) Photographic paper glued onto glass without bending the edges. (5) Photographic paper glued onto glass with edges bent. (6) Photographic paper glued onto mat glass. (7) semi-mat. (8) high-gloss. (9) From measuring grids. (10) From aerial photographs.

Table 2.

	(1) Диапозитивы		(2) Фотобумага, наклеенная на стекло без загиба краев				(3) Фотобумага, наклеенная на стекло с загибом краев				(4) Фотобумага, наклеенная на матированное стекло			
			(5) полуматовая		(6) особо глянцевая		(5) полуматовая		(6) особо глянцевая		(5) полуматовая		(6) особо глянцевая	
	Δp	q	Δp	q	Δp	q	Δp	q	Δp	q	Δp	q	Δp	q
(7) Сумма	745	568	731	982	782	1153	682	933	493	940	846	995	873	1588
(8) Средние значения	8,3	6,3	8,1	10,9	8,7	12,8	7,6	10,4	5,5	10,4	9,4	11,1	9,7	17,9
(9) Максимальные значения	29	20	27	38	38	34	27	32	14	32	30	37	27	38

KEY: (1) Diapositives. (2) Photographic paper glued onto glass without bending edges. (3) Photographic paper glued onto glass with edges bent. (4) Photographic paper glued onto mat glass. (5) semi-mat. (6) high-gloss. (7) Overall. (8) Mean values. (9) Maximum values.

Table 3.

(1) Расхождения поперечных параллаксов	(2) Диапозитивы	(3) Фотобумага, наклеенная на стекло без загиба краев		(4) Фотобумага, наклеенная на стекло с загибом краев		(5) Фотобумага, наклеенная на матированное стекло	
		(6) полуматовая	(7) особо глянцевая	(6) полуматовая	(7) особо глянцевая	(6) полуматовая	(7) особо глянцевая
$(q_{изм} - q_{выч})_{ср}$ (8)	21	34	29	25	31	29	21
$(q_{изм} - q_{выч})_{max}$	45	82	66	72	62	81	72

KEY: (1) Divergence of transverse parallaxes. (2) Diapositives. (3) Photographic paper glued onto glass without bending edges. (4) Photographic paper glued onto glass with edges bent. (5) Photographic paper glued onto mat glass. (6) semi-mat. (7) high-gloss. (8) Mean.

Table 4.

	(1) Диапозитивы	(2) Фотометрические пластинки	(3) Фотобумага, наклеенная на стекло без загиба краев		(4) Фотобумага, наклеенная на стекло с загибом краев	
			(5) полуматовая	(6) особо глянцевая	(5) полуматовая	(6) особо глянцевая
(7) Количество точек	51	49	51	50	47	50
(8) Средняя ошибка, м	0,33	0,42	0,42	0,43	0,47	0,48
(9) Максимальная ошибка, м	0,9	1,2	1,3	1,3	0,9	1,2

KEY: (1) Diapositives. (2) Photometric plates. (3) Photographic paper glued onto glass without bending edges. (4) Photographic paper glued onto glass with edges bent. (5) semi-mat. (6) high-gloss. (7) Number of points. (8) Mean error, m. (9) Maximum error, m.

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